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Field Crops Research 97 (2006) 176–181

Field Crops Research

www.elsevier.com/locate/fcr

Fiber composition of eastern gamagrass forage grown on a degraded, acid soil

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Received 22 March 2005; accepted 19 September 2005

Abstract

With increasing emphasis on sustainable agriculture, there is renewed interest in the use of native plants as alternative sources for food, fiber, and soil improvement. Eastern gamagrass [*Tripsacum dactyloides* (L.) L.] is a native, warm-season, perennial grass found in the eastern United States that has been used for forage and soil improvement. The objective of this research was to investigate the forage composition and digestibility of eastern gamagrass grown on a degraded, acid soil at the Beltsville Agricultural Research Center, Beltsville, MD. Eastern gamagrass forage samples were harvested at time of heading in July of 1997, 1998, and 1999 from plants grown on a degraded hillside with increasing soil acidity and decreasing surface soil depth from the bottom to top of the hillslope and analyzed for fiber, crude protein, and in situ digestibility. Year of harvest had the greatest effect on forage composition. Fiber composition was related to slope position and soil acidity. Plants were generally high in fiber as reflected by high neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents, but were not particularly high in lignin. Crude protein (6–11%) and digestibility were good. In general, forage quality, as indicated by lower fiber (NDF, ADF, lignin) and higher digestibility and crude protein, increased as soil condition degraded and environmental stress (deficit rainfall) increased. Thus, eastern gamagrass is comparable in forage composition and digestibility to many forages currently used even when grown on poor soil and under environmental stress.

Keywords: Eastern gamagrass; Forage; Fiber; Crude protein; Digestibility; Fiber composition

1. Introduction

With increasing emphasis on sustainable agriculture, there is increased interest in using native plants as alternative crops for food, fiber, and soil improvement. Eastern gamagrass [*Tripsacum dactyloides* (L.) L.] is a native, warm-season, perennial bunch grass that is found from the east coast to western Kansas and from Florida to upper New York in the United States (Dickerson et al., 1997; Ritchie et al., 2000) that has been used for livestock forage (Horner et al., 1985; Coblentz et al., 1999). It grows in acid, Al-toxic soils that are severely restricting to most crop plants (Foy, 1997; Foy et al., 1999).

Eastern gamagrass produces high yields of forage (Krizek et al., 2003) with reported protein content and palatability comparable to values for alfalfa forage (Horner et al., 1985; Bidlack et al., 1999). Although reports have shown eastern gamagrass to be a high quality and high producing forage compared to other forage plants, relatively little research has been done concerning the effects of soil conditions on forage quality and fiber composition (Burns et al., 1991; Coblentz et al., 1999). The objective of our research was to investigate the fiber composition and digestibility of eastern gamagrass forage grown on a degraded, acid soil at the Beltsville Agricultural Research Center, Beltsville, MD, USA.

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doi:10.1016/j.fcr.2005.09.007

2. Methods and materials

2.1. Study site

Eastern gamagrass, cultivar Pete, was planted in 1996 on six sites located along a 240 m hillslope having a 22% slope (Fig. 1) on a degraded phase of Matawan–Hammonton loam soil complex. This soil complex contained less than 15% gravel and ranged in texture between clay loam and loamy sand with low soil pH and generally poor soil conditions (Foy et al., 1999). The A horizons became thinner from the bottom to the top of the hillslope (Sites 1–6) indicating greater erosion and soil degradation at the upper slope sites (USDA, 1995). Soil pH (1:1 soil–water suspension) in the surface layer (USDA, 1995) varied from 5.1 at the bottom of the slope (Site 1) to 4.3 at the top of the hillslope (Site 6). Bulk density measurements at depths of 0–15, 15–30, and 30–45 cm ranged from 0.98 to 1.24 g cm^{-3} at the bottom of the hillslope to 1.16 to 1.64 g cm^{-3} at the top of the hillslope (Krizek et al., 2003). Prior to planting eastern gamagrass, the hillslope had mixed grasses dominated by tall fescue [*Festuca arundineacea* Schreb.] that had not been plowed for more than 30 years.

Site 1, located at the bottom of the hillslope, consisted of nine 4 m × 4 m plots described in detail by Foy et al. (1999). Sites 2–6 were located up the hillslope from Site 1 with Site 6 being at the top of the hillslope (Fig. 1). Site 1 was chisel plowed to a depth of 30 cm and then roto-plowed to a depth of 15 cm prior to hand planting seed. Sites 2–6 were no-till planted with a corn planter after application of ROUND-UP™ to kill the sod.

Sites 2–6 ranged in size from 100 to 200 m^2 with 12–18 rows each. All sites were fertilized with 19–19–19 at 560 kg ha^{-1} in the spring of 1996, 1997, and 1998 and with 336 kg ha^{-1} in the spring 1999. Eastern gamagrass at Site 1 was planted in 46-cm rows while Sites 2–6 were planted in 75-cm rows. Yield data have now been collected over a 9-year period (1997–2005) from each site.

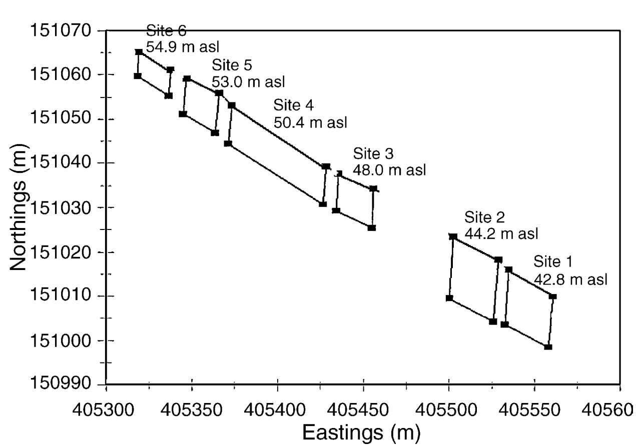

Fig. 1. Physical layout of the eastern gamagrass study plots. Site number and elevation above sea level (asl) are given.

2.2. Rainfall

Total rainfall in 1997, 1998, and 1999 was 832, 888, and 1022 mm, respectively. These values represent a deficit of 242, 179, and 45 mm for 1997, 1998, and 1999, respectively, when compared to the average yearly rainfall of 1067 mm for the period between 1871 and 2000 at the Baltimore–Washington International Airport located approximately 30 km northeast of the study site. However, 290 mm (28%) of the 1022 mm for 1999 came in September after the growing season, thus the deficit for 1999 would be 235 mm during the growing period. Only 351, 498, and 270 mm came during the harvesting period (March–July) of 1997, 1998, and 1999, respectively. For 1997, 1998, and 1999, these values were 76, 108, and 59%, respectively, of the average rainfall (459 mm) for the growing period.

2.3. Sampling

Eastern gamagrass forage was harvested at time of heading from each site in 1997 (July 22), 1998 (July 20), and 1999 (July 1). An early season sample was harvested and analyzed for forage composition in 1998 (June 3). Samples for forage biomass and composition analyses were collected using two 1-m strips for each site. For Site 1, forage samples were collected from three plots that had not received lime during a previous study (Foy et al., 1999). Samples were dried in a forced-draft oven at 60 °C for 72 h, weighed for biomass determination, and ground with a Wiley mill.[1]

2.4. Forage composition determination

Previously ground forage samples were mixed, sub-sampled, and reground to pass a 1-mm screen. Triplicate samples were analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin in the ADF residue using the fiber bag modification (Vogel et al., 1999) of methods described by Goering and Van Soest (1970) except that sodium sulfite was eliminated and triethylene glycol was substituted for 2-ethoxyethanol to control foaming (Cherney, 2000). Hemicellulose was computed as the difference between the NDF and ADF. Cell wall digestibility (CWDIG) or in situ NDF and dry matter digestibility (DMDIG) were determined by incubating samples (quadruplicates) in polyester bags for 72 h in steers fed a typical dairy diet (Tilley and Terry, 1963; White et al., 1981). Cell wall digestibility was computed as the percent of the initial NDF remaining after the 72 h in situ digestion. Total carbon and nitrogen for each sample were determined for duplicate samples by combustion with a Leco Carbon–Nitrogen analyzer[1] (Nelson and Sommers, 1996) and nitrogen was used to calculate total crude protein.

[1] Trade names are included for the benefit of the reader and do not imply an endorsement of or a preference for the product listed by the U.S. Department of Agriculture.

2.5. Statistical analysis

Statistical analyses were made using Statistix (Analytical Software, 2003) to test for differences between means in fiber composition and digestibility using one-way ANOVA and the least significant difference (LSD) tests.

3. Results

3.1. Biomass

Total biomass from the harvests of eastern gamagrass forage in 1997, 1998, and 1999 averaged for the six sites was 4261, 4995, and 2288 kg ha^{-1}, respectively, reflecting the poor moisture conditions during those years. Biomass varied more than two-fold and decreased from the bottom to the top of the hillslope. See Krizek et al. (2003) for detailed analyses of biomass production for the sites for 1997–2000.

3.2. Forage composition

Eastern gamagrass forage was high in fiber but low in lignin (Table 1). Hemicellulose ranged from 19 to 39% with an average of 31%. Crude protein of the eastern gamagrass forage ranged from 6 to 11% with an average of 8.5%. Cell wall digestibility ranged from 30 to 55% with an average of 44% and DMDIG ranged from 44 to 68% with an average of 59%.

Examination of the effect of the time of harvest in 1998 on forage composition (Table 2) shows that harvest date had a significant effect on ADF, NDF, DMDIG, CWDIG, and crude protein. Forage samples from the first harvest (June 3, 1998) were higher in ADF, NDF, and CWDIG and lower in crude protein and DMDIG than samples from the second harvest (July 29, 1998).

Forage composition of eastern gamagrass varied significantly with year of harvest (Table 3). The forage harvested in 1999 had significantly more fiber (ADF and NDF) and was less digestible (CWDIG and DMDIG) than that in 1997 and 1998 (Table 3). There was a 41% deficit in rainfall during the harvest period (March–July) in 1999 as compared to a deficit of 24% in 1997 and a surplus of 8% in 1998. High fiber (ADF and NDF) and low digestibility were found during the large deficit rainfall period in 1999 (Table 4).

The effects of slope position on forage composition and digestibility of eastern gamagrass are shown in Table 5. In general, fiber content decreased from the bottom (Site 1) to the top (Site 6) of the hillslope while digestibility and crude protein increased along the same gradient. In general, the surface soil depth decreased from the bottom (Site 1) to the top (Site 6) of the hillslope and compaction increased (USDA, 1995; Krizek et al., 2003) indicating decreasing soil quality and poorer growing conditions for plants along this slope gradient. Soil acidity also had significant effects on forage composition and digestibility (Table 6). As soil acidity increased fiber content decreased and digestibility and crude protein increased.

4. Discussion

Eastern gamagrass forage in this study was comparable in fiber and protein composition to other common forage plants (Reeves, 1987a,b; Van Soest, 1994). Its relatively high average crude protein content (8.5%) would place it in the category of high quality forages (9–18%) such as alfalfa [*Medicago sativa* L.], orchard grass [*Dactylis glomerata* L.], and sudan grass [*Sorghum drummondii* (Steud.) Millsp. & Chase] as defined by Kellems and Church (2001). These same high quality forages had NDF contents of 47, 50, and 68%, respectively, and ADF contents of 35, 29, and 43%, respectively. Thus, with an average NDF of 73% and ADF of 43%, eastern gamagrass forage would tend to be higher in fiber and in the lower quality forages as defined by Kellems and Church (2001) where NDF and ADF contents of 70–88 and 39–67%, respectively, were common. With an average DMDIG of 59%, eastern gamagrass forage would not be as high as that of early harvest alfalfa at 68%, but would be comparable to that of late harvest alfalfa (54%), and better than that of mature timothy [*Phleum pratense* L.] forage (47%) (Van Soest, 1994). Comparing eastern gamagrass forage composition to other forage studies at Beltsville (Reeves, 1987a), the average CWDIG value of 45% was comparable to that found for many cuttings of alfalfa, but lower than that measured for tall fescue or orchard grass. The average NDF content in our eastern gamagrass was higher than the NDF contents of these forages (Reeves, 1987a). For the ADF, the differences were even greater with the average eastern gamagrass having much higher ADF content.

A comparison of eastern gamagrass forage composition with six forages (alfalfa, tall fescue, a mixed forage, orchard grass, red clover [*Trifolium pratense* L.] and timothy) used in a chemical treatment study (Reeves, 1987b) indicates that the average DMDIG for eastern gamagrass was similar to that for other species (62% for 48 h in vitro) except alfalfa (69%) and orchard grass (68%). Although the methods used for many of these studies vary somewhat, the overall picture indicates that eastern gamagrass is comparable in overall

Table 1
Means and standard deviations for forage composition of eastern gamagrass for all years (1997–1999) and all sites (1–6)

	ADF (%)	NDF (%)	Hemicellulose (%)	Lignin (%)	DMDIG (%)	CWDIG (%)	Carbon (%)	Crude protein (%)
Samples	42.5 ± 4.9	73.4 ± 3.6	30.9 ± 4.2	5.0 ± 1.4	58.9 ± 4.4	43.9 ± 4.8	47.1 ± 1.5	8.5 ± 1.4
Range	32.8–58.3	63.7–83.3	18.8–38.7	1.2–8.3	43.8–67.9	29.8–54.7	44.1–49.1	5.6–11.1

ADF: acid detergent fiber; NDF: neutral detergent fiber; DMDIG: dry matter digestibility; CWDIG: cell wall digestibility.

Table 2
Means and standard deviations for forage composition of eastern gamagrass by harvest date for 1998

Harvest date, 1998	ADF (%)	NDF (%)	Hemicellulose (%)	Lignin (%)	DMDIG (%)	CWDIG (%)	Carbon (%)	Crude protein (%)
June 03	45.3 ± 5.1a	76.7 ± 3.2a	31.4 ± 3.6a	4.9 ± 1.3a	58.2 ± 2.7b	46.1 ± 3.6a	47.9 ± 0.5a	7.5 ± 0.6b
July 29	40.8 ± 4.2b	70.8 ± 1.7b	29.9 ± 4.2a	4.5 ± 1.4a	59.7 ± 3.0a	43.0 ± 4.0b	47.8 ± 0.5a	8.1 ± 1.1a
ANOVA, *F*-value	25.1, $p = 0.001$	142.0, $p = 0.001$	3.92, $p = 0.050$	2.62, $p = 0.109$	8.87, $p = 0.0045$	20.8, $p = 0.001$	0.79, $p = 0.375$	7.74, $p = 0.007$

Means with different letters in a column are different at the 0.05 level of probability. ADF: acid detergent fiber; NDF: neutral detergent fiber; DMDIG: dry matter digestibility; CWDIG: cell wall digestibility.

Table 3
Means and standard deviations for forage composition of eastern gamagrass by year

Year	ADF (%)	NDF (%)	Hemicellulose (%)	Lignin (%)	DMDIG (%)	CWDIG (%)	Carbon (%)	Crude protein (%)
1997	40.2 ± 3.8b	71.2 ± 2.4b	30.9 ± 3.8ab	5.0 ± 1.6ab	62.1 ± 3.0a	46.7 ± 3.9a	44.6 ± 0.4c	9.5 ± 1.4a
1998	40.8 ± 4.2b	70.2 ± 1.7b	29.9 ± 4.2b	4.5 ± 1.4b	59.7 ± 3.0b	43.0 ± 4.0b	47.8 ± 0.5b	8.0 ± 1.1b
1999	44.8 ± 4.9a	76.2 ± 2.9a	31.4 ± 4.3a	5.2 ± 1.3a	56.2 ± 4.4c	42.7 ± 5.1b	48.2 ± 0.4a	8.1 ± 1.3b
ANOVA, *F*-value	23.7, $p = 0.001$	111.0, $p = 0.001$	2.2, $p = 0.111$	4.4, $p = 0.014$	50.6, $p = 0.001$	17.2, $p = 0.001$	704.0, $p = 0.001$	15.1, $p = 0.001$

Means with different letters in a column are different at the 0.05 level of probability. ADF: acid detergent fiber; NDF: neutral detergent fiber; DMDIG: dry matter digestibility; CWDIG: cell wall digestibility.

digestibility to many forages in use today. The average NDF content of 73% was similar to that of the orchard grass forage (74%) but lower than for fescue (82%) and timothy (83%) forages. For CWDIG, eastern gamagrass forage was similar to alfalfa and red clover forages, which had CWDIG levels of 38 and 33% respectively. However, the alfalfa and red clover forages had much lower total NDF contents (50 and 59%, respectively). Thus, eastern gamagrass appears similar to legume forage in having lower digestibility than grass forages but is similar to other grass forages possessing a high overall fiber content.

Time of harvest in 1998 (Table 2) shows that samples taken during the first harvest (June 3, 1998) were higher in ADF, NDF, and CWDIG and lower in crude protein and DMDIG than samples from the second harvest (July 29, 1998) in early summer. This is the opposite of what is found with many forages where the first or early cutting material is of higher quality (lower fiber, higher crude protein, and digestibility) than later cuttings (Coblentz et al., 1999). Overall, our results indicate that forage cut from regrowth in 1998 was of better quality than the first cutting.

When compared to other forages such as alfalfa or orchard grass, the production of better quality forage at the second harvest rather than the first harvest is unusual. Kellems and Church (2001) found that crude protein in orchard grass steadily decreased from 25% in May (cut 5/19) to 12% in June (6/27). Crude fiber digestibility likewise decreased from 81 to 68% over the same time period while crude fiber content increased from 27 to 35%. Similar results were obtained for alfalfa-brome forage. However, in tall fescue, the crude protein content and crude fiber digestibility decreased over a similar time span, as well as the crude fiber content. Thus, our results for eastern gamagrass appear to be somewhat unusual in the changes in composition and digestibility, which occur between first and second harvests in 1998. These differences could be accounted for partially by differences in environmental conditions between the early and later growing periods and partially by the differences in biochemical and structural differences between the two time periods.

Eastern gamagrass forage composition varied significantly with year of harvest (Table 3). High fiber (ADF and NDF) and low digestibility were found during the large

Table 4
Means and standard deviations for forage composition of eastern gamagrass by harvest period rainfall (March–July)

Rain (mm)	ADF (%)	NDF (%)	Hemicellulose (%)	Lignin (%)	DMDIG (%)	CWDIG (%)	Carbon (%)	Crude protein (%)
270	44.7 ± 4.9a	76.2 ± 2.9a	31.4 ± 4.3a	5.2 ± 1.3a	56.2 ± 4.4c	42.7 ± 5.1b	48.2 ± 0.4a	8.1 ± 1.3b
351	40.8 ± 3.8b	71.1 ± 2.4a	30.9 ± 3.8ab	5.0 ± 1.6ab	62.1 ± 3.0a	46.7 ± 3.0a	44.6 ± 0.4c	9.5 ± 1.4a
498	40.8 ± 4.2b	70.8 ± 1.7b	29.9 ± 4.2b	4.5 ± 1.4b	59.7 ± 3.0b	43.0 ± 4.0b	47.8 ± 0.5b	8.0 ± 1.1b
ANOVA, *F*-value	23.7, $p = 0.001$	111.0, $p = 0.001$	2.23, $p = 0.111$	4.40, $p = 0.014$	50.6, $p = 0.001$	17.2, $p = 0.001$	704.0, $p = 0.375$	15.1, $p = 0.007$

Means with different letters in a column are different at the 0.05 level of probability. ADF: acid detergent fiber; NDF: neutral detergent fiber; DMDIG: dry matter digestibility; CWDIG: cell wall digestibility.

Table 5
Means and standard deviations for forage composition of eastern gamagrass by site

Site	ADF (%)	NDF (%)	Hemicellulose (%)	Lignin (%)	DMDIG (%)	CWDIG (%)	Carbon (%)	Crude protein (%)
1	45.5 ± 5.4a	74.4 ± 5.8a	28.9 ± 4.3b	5.4 ± 1.2a	57.3 ± 6.4cd	42.2 ± 5.1bc	46.7 ± 1.5a	7.8 ± 1.0c
2	42.8 ± 4.6b	73.3 ± 3.2ab	30.4 ± 4.1ab	5.2 ± 1.5a	56.7 ± 4.3d	41.1 ± 4.6c	47.0 ± 1.6a	7.8 ± 1.4c
3	42.7 ± 4.4b	74.3 ± 2.9a	31.6 ± 3.5a	4.8 ± 1.3a	58.6 ± 3.1bc	44.2 ± 4.0ab	46.7 ± 1.5a	7.9 ± 1.6c
4	41.9 ± 4.6bc	73.1 ± 2.3ab	31.3 ± 4.4a	5.1 ± 1.4a	60.6 ± 3.3a	46.1 ± 4.5a	47.5 ± 1.5a	8.9 ± 1.0b
5	41.3 ± 5.0bc	72.0 ± 4.2b	30.6 ± 4.0ab	4.8 ± 1.6ab	60.8 ± 3.8a	45.5 ± 4.3ab	47.3 ± 1.5a	9.0 ± 1.1b
6	39.8 ± 4.3c	72.0 ± 2.5b	32.2 ± 4.5a	4.1 ± 1.4bc	60.0 ± 3.2ab	44.0 ± 4.4abc	47.2 ± 1.7a	9.9 ± 1.0a
ANOVA, *F*-value	4.75, $p = 0.0004$	2.57, $p = 0.028$	2.49, $p = 0.033$	2.98, $p = 0.013$	6.06, $p = 0.001$	6.63, $p = 0.001$	0.92, $p = 0.470$	8.46, $p = 0.001$

Site 1 is at the bottom of the hillslope and Site 6 is at the top of the hillslope. Means with different letters in a column are different at the 0.05 level of probability. ADF: acid detergent fiber; NDF: neutral detergent fiber; DMDIG: dry matter digestibility; CWDIG: cell wall digestibility.

Table 6
Means and standard deviations for forage composition of eastern gamagrass by soil pH

pH	ADF (%)	NDF (%)	Hemicellulose (%)	Lignin (%)	DMDIG (%)	CWDIG (%)	Carbon (%)	Crude protein (%)
>5.0	44.1 ± 5.2a	73.8 ± 4.6a	29.7 ± 4.2b	5.2 ± 1.4a	57.0 ± 5.5b	41.7 ± 4.9b	46.9 ± 1.6a	7.8 ± 1.2b
4.5–5.0	42.7 ± 4.4ab	74.3 ± 2.9a	31.6 ± 3.5a	4.8 ± 1.3ab	58.6 ± 3.1b	44.2 ± 4.0a	46.7 ± 1.5a	7.9 ± 1.6b
<4.5	41.2 ± 4.6b	72.6 ± 3.0b	31.4 ± 4.3a	4.8 ± 1.5b	60.5 ± 3.4a	45.4 ± 4.5a	47.3 ± 1.5a	9.2 ± 1.1a
ANOVA, *F*-value	7.37, $p = 0.001$	4.37, $p = 0.014$	4.15, $p = 0.002$	2.89, $p = 0.058$	14.8, $p = 0.001$	14.0, $p = 0.001$	2.02, $p = 0.138$	17.2, $p = 0.001$

Means with different letters in a column are different at the 0.05 level of probability. ADF: acid detergent fiber; NDF: neutral detergent fiber; DMDIG: dry matter digestibility; CWDIG: cell wall digestibility.

deficit rainfall period in 1999 (Table 4). While rainfall appears to play a factor in eastern gamagrass forage composition, it is not the only factor since forage composition for a year (1998) with normal rainfall had lower digestibility than when grown during a year having a deficit in rainfall (1997). It appears that under water limiting conditions, fiber increases and digestibility decreases (Table 4). However, crude protein content (9.5%) was highest in 1997 with some rainfall deficit while the crude protein content of 1999 (high rainfall deficit) and 1998 (normal rainfall) forage was lower (8.1 and 8.0%, respectively) and not significantly different from each other. Thus, a deficit in rainfall appears to affect forage composition, but not necessarily in a linear manner. Water availability, soil conditions, maturity, and harvest interval have been cited as factors responsible for the variability in forage composition of eastern gamagrass (Brejda et al., 1997).

In general, fiber content decreased from the bottom (Site 1) to the top (Site 6) of the hillslope (Table 5) while digestibility and crude protein increased along the same gradient where the surface soil depth was decreasing and compaction increasing (USDA, 1995; Krizek et al., 2003) indicating a decrease in soil quality and poorer growing conditions for plants along this slope gradient. Also as soil acidity increased along this gradient (Table 6), fiber content decreased and digestibility and crude protein increased.

Crude protein content is a good measure of forage quality because it is a highly valued constituent and forages with high protein levels are generally more digestible and have lower fiber contents. As shown (Tables 5 and 6) crude protein content of eastern gamagrass increased with slope position (increasing soil degradation), increasing soil acidity, and decreasing surface soil depth indicating higher quality forage of eastern gamagrass under poorer growing conditions than for most plants (Foy et al., 1999). Slope position, soil degradation (depth of A horizon), and soil pH were highly correlated so determining their individual effects on eastern gamagrass production and forage composition was not possible. However, forage quality as indicated by lower fiber (ADF, NDF, lignin) and higher digestibility and crude protein increased as soil condition degraded and environmental stress (deficit rainfall) increased.

5. Conclusions

Eastern gamagrass growth was probably limited by soil moisture during 1997 and especially during the 1999 growing season. Sampling was limited to one harvest in 1999 because of the poor growth of eastern gamagrass from April to July with the first heading not until early July of 1999. Time and year of harvest generally had a greater effect on forage composition than did site location. Plants were generally high in fiber as reflected by high NDF and ADF contents. Crude protein and digestibility, while not as high as found in some forages, were good and similar to values reported by others. In general, forage quality as indicated by lower fiber (NDF, ADF, lignin) and higher digestibility and crude protein increased as soil condition degraded and environmental stress (deficit rainfall) increased. This study demonstrated that eastern gamagrass produced good quality forage under marginal soil and environmental conditions. As a warm-season forage, eastern gamagrass can provide good forage in the warm summer months when the cool season forage production is limited.

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